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INSECT PARASITE INTRODUCTION IN PORTO RICO.

By GEORGE N. WOLCOTT.

Because of the difficulty and comparative lack of success in controlling white grubs in Porto Rico by artificial and mechanical means, and the scarcity of any important native parasites and predators on them, one of the first acts of Mr. D. L. Van Dine, the first Entomologist at the Estación Experimental at Río Piedras, was to arrange for the importation of promising parasites of white grubs of other countries into Porto Rico. Mr. C. E. Hood was employed to collect and ship them to Porto Rico, and as the natural enemies of white grubs in the United States had been most thorougly studied in Illinois by Prof. S. A. Forbes, he made his headquarters in Professor Forbes' laboratory at the University of Illinois.

The most important and abundant parasite of white grubs in the northern United States is an entirely black wasp, covered with grey hairs, *Tiphia inornata* Say., or rather various species of the genus *Tiphia*. (Fig. 1.) The females of this wasp have wings and can fly, but actually spend the greater portion of their time on or in the ground, searching for white grubs on which to lay their eggs. The grub is stung by the wasp so that it will remain temporarily quiet during, and for a short time after, the deposition of the egg on its body. (Fig. 2.) The white maggot of the wasp, which hatches in a few days, grows rapidly, sucking the juices out of the white grub to which it is attached and eventually killing and destroying it, so that nothing is left but the shriveled skin of the body of the grub and its hard legs and head. In the cavity in the soil which was previously occupied by the white grub, the wasp maggot spins its bottle-shaped cocoon of yellowish-brown silk, attaching one end firmly to the side-wall of the cavity in the earth. There may be one or sometimes two generations of the wasps in a year, but the winter is

spent in the cocoon, and it is at this season and in this stage that it could be transported in large numbers alive to a foreign country. In the year that Mr. Hood was employed, he sent 23 cocoons to Porto Rico, from one of which an adult emerged. After Mr. Hood's death, Mr. George N. Wolcott was appointed to continue the work and he collected *Tiphia* cocoons in Illinois for two years, until appointed En-

FIG. 1.—Adult female of *Tiphia transversa* Say. (After Davis.)[1]

tomologist at the reorganized Insular Experiment Station in the fall of 1914.

It was found that the most practical and effective method of collecting *Tiphia* cocoons was by taking advantage of the normal

[1] To Prof. Stephen A. Forbes, Chief of the Illinois State Natural History Survey, the writer is greatly indebted for permission to use the illustrations appearing in this article, which were published in the paper by Mr. John J. Davis "Contributions to a Knowledge of the Natural Enemies of *Phyllophaga*", Art. V, Vol. XIII, Bull. Ill. Nat. Hist. Survey, Feb. 1919.

processes of agriculture, that is, by following the plow in promising fields being plowed, where white grubs were, or rather had been, abundant. The *Tiphia* wasps are such efficient parasites in Illinois that in two or three years after the appearance of the few females in a field heavily infested with grubs, nearly all will have been parasitized, and the next year neither grubs nor live parasites will be present in the soil, only the empty rotten cocoons of *Tiphia*, a relic of their presence and of their having exterminated the white grubs (1).[1] Most of the plowing in Illinois is done in the fall and for a short period in the spring and the collection of *Tiphia* cocoons there was confined to these seasons of the year.

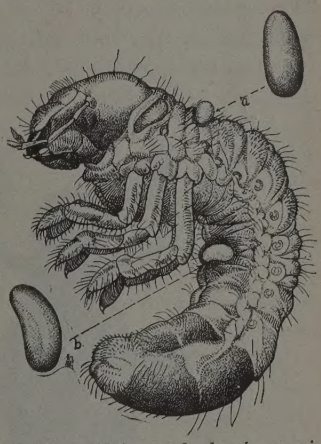

FIG. 2.—White grub showing position of *Tiphia* eggs; *a*, *Tiphia punctata* Rob.; *b*, *T. transversa* Say, and eggs much enlarged. (After Davis.)

Attempts were made to collect *Tiphia* cocoons in Texas and Louisiana in the early winter, but although white grubs were found in abundance, very few cocoons were collected, none in Texas and only 19 in Louisiana in 1912 and none there in 1913.

From the autumn of 1912 to the autumn of 1914, inclusive, a total of 2,560 *Tiphia* cocoons was collected in Illinois and sent to Porto Rico by Mr. Wolcott, as shown in the accompanying table.

TABLE.

	Number of cocoons.	Per cent of adults emerging.	Per cent of live adults released in breeding cages.
Tiphia cocoons collected in Illinois during the fall of 1912	540	38 per cent	33 per cent.
Spring of 1913	500	20 per cent	15 per cent.
Fall of 1913, sent to Porto Rico fall	101	29 per cent	26 per cent.
Sent to Porto Rico spring	855	44 per cent in 11 days	44 per cent.
Spring of 1914	234	27 per cent in 7 days	27 per cent.
Fall of 1914, sent to Porto Rico spring	330	71 per cent in 10 days. 79 per cent total.	79 per cent released in the field, Tablón No. 7, Hda. Sta. Rita.

The increase in the number of adults emerging and of live adults

[1] Numbers refer to "Literature Cited." See p. 19.

available for breeding and release in Porto Rico indicates the perfection of proper methods of shipment and of caring for the cocoons. At first cocoons were packed 25 or 30 together in small tin salve boxes, placed in paper mailing tubes and sent by first-class mail. The cocoons in a box, all of which appeared healthy when shipped, might arrive in Porto Rico covered with the white mycelium of a fungus, *Isaria,* which had killed all the insects inside them, having spread from one infested cocoon. Placing each cocoon in a separate, cork or cotton stoppered glass vial, or in a gelatine capsule, confined the fungus to the cocoon where it occurred.

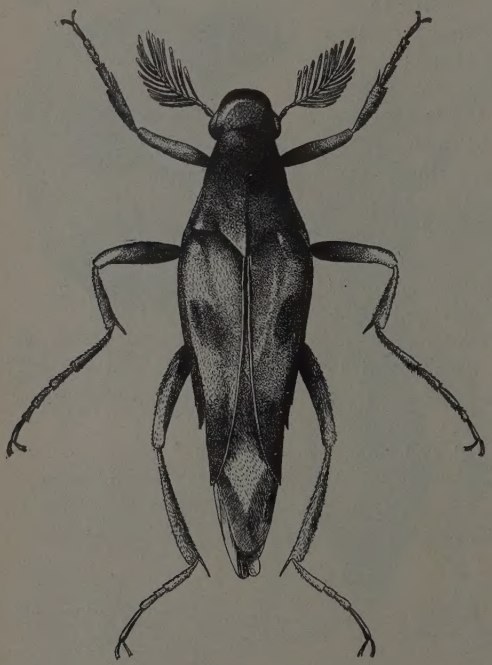

FIG. 3.—Adult of *Macrosiagon* (*Rhipiphorus*) *pectinatus* Fabr., a parasite of *Tiphia.* (After Davis.)

This fungus also caused heavy mortality in Porto Rico until the most satisfactory method of keeping the cocoons for the emergence of the adults was learned from Mr. S. A. Rohwer, Curator of Hymenoptera, U. S. National Museum. This was by putting the cocoons in sterilized glass tubes, the bottoms of which were plugged with plaster of Paris, which allowed sufficient moisture to come up from the moist sand on which they were placed. Adults emerging in such tubes would be immediately observed and removed to the breeding cages. The emergence of parasites of the wasps would also be observed and these removed and killed. Some of the beetles, *Rhipiphorus pectinatus* Fabr., recorded by Dr. Riley (2) from Missouri, were

found in the cocoons sents to Porto Rico (Fig. 3.) and two more species of Bombyliid flies emerged, in addition to the *Exoprosopa fascipennis* Say. recorded by Dr. Forbes (3). These have been determined by Mr. C. T. Greene as *Exoprosopa fasciata* Macq. and *Anthrax fulvohirta* Wied.

At first cocoons were sent to Porto Rico as soon as collected. From those collected in the fall, some wasps would be stimulated by the tropical warmth to emerge in November, while those that had not transformed from the larval or pupal stage before leaving the States might not emerge till January or February. The results was that at no time during the winters of 1912–13 and 1913–14 was any large number of wasps alive and active, but their emergence was scattered over a period of three or four months. Despite this discouraging scattering emergence, when often only adults of one sex might be alive, some Illinois *Tiphia* female wasps, from cocoons collected in the first autumn (1912) did oviposit on Porto Rico white grubs (*Lachnosterna vandinei* Smyth, from Hacienda Santa Rita) in the large (3 ft. × 3 ft. × 6 ft.) breeding cage in the insectary at Río Piedras, under the care of Mr. Thos. H. Jones. On two grubs the eggs hatched and the maggots increased perceptibly in size, but when next observed the maggots had been rubbed off, only a brown scar on the back showing where they had been, and these white grubs developed normally to beetles. Occasionally grubs showing similar scars were observed in the course of the collecting in Illinois, and indicate that the wasp did not sting the grub sufficiently, or that she had chosen a species of grub that was larger or more active than the one ordinarily parasitized by that species of *Tiphia*. Mr. Jones was of the opinion that the disturbance of the grubs incident to digging them up to find if any were parasitized and placing them in smaller cans for observation might have caused the wasp maggot to loose its hold, and thereafter the soil in the breeding cages was never disturbed by looking to see whether the wasps were successful in parasitizing the grubs.

In the spring of 1913 the breeding work with the wasps was transferred to the South Coast Laboratory at Hacienda Santa Rita (Guánica, near Yauco), of which Mr. E. G. Smyth was in charge, where they were released in a large (6 ft. wide, 10 ft. long and 3 ft. high) outdoor cage on the ground, abundantly supplied with growing sugar-cane and white grubs in the soil. Some live wasps which had emerged at Río Piedras were put in these cages, but most of them were from cocoons shipped direct from Illinois.

In the fall of 1913, only a small portion of the cocoons collected were sent at once to Porto Rico, but about nine-tenths of them, after being put in individual capsules or glass vials, were packed in two 2-quart tin pails and put into cold storage for the winter in a commercial cold-storage plant where the University of Illinois had a large cabinet for the reception of hibernating insects. Late in the next spring, these two pails were packed in an ice-cream tub and sent by insured express to the New York office of Guánica Centrale, which transferred them to the ship's refrigerator, from which they were not removed until reaching Ensenada harbor at Guánica. Thus these cocoons were in cold storage from late fall till June 1st, when they arrived within a few miles of the laboratory in Porto Rico. From the 855 cocoons,

6 live wasps emerged June 1,
75 on June 2d,
82 on June 3d,
97 on June 4th,
68 on June 6th and 7th,
35 on June 8th and 9th, and the final
16 on June 10th and 11th, making a total of

379, or 44 per cent of the wasps emerging in 11 days,

very much the best record, both for percentage of emergence and for the short time in which it occurred.

Most of the adults from the cocoons collected in the spring also emerged within a short period (7 days) in mid-May, and the outdoor breeding cage at Santa Rita was well supplied with both sexes of several species of *Tiphia* wasps at this time. When the ground under the cage was dug up later in the year, none of the grubs showed signs of being parasitized, nor were any *Tiphia* cocoons found. Thus this attempt to breed a second generation of Illinois *Tiphia* on Porto Rican white grubs in a cage, under supposedly the most favorable conditions, was an absolute failure. For a period of about three hours on June 6th, 8th, 10th and 12th, the door of the cage had been left open, so that fertilized females might search for grubs in the field, if the environment in the cage had not proved favorable, but it is doubtful if many did escape from the cage, at least none were seen in the yard surrounded by high masonry walls back of the Casa Grande where the cage was located.

Thus despite the careful working out of methods of collection and shipment of *Tiphia* cocoons, so as to have large numbers of

adults alive at one time for breeding or release in the field, the parasite introduction had failed in that not a single wasp maggot had been able to complete its development on a Porto Rican white grub in captivity.

In the fall of 1914, a final collection of *Tiphia* cocoons was made in Illinois, and left there in cold storage, to be sent to Porto Rico the following spring. Dr. Robert H. Glasgow of the University of Illinois, who took charge of starting them from Illinois, placed them in a pail with a friction-top, waterproof cover for shipment in the ice-cream tub. They arrived in Porto Rico in much better condition than the shipment of the year before which had been made in a pail with an insecurely fitting cover that had permitted the water to leak in. This is reflected in the 71 per cent of emergence of adults within ten days after receipt, and a total emergence of 79 per cent. No attempt was made to breed a second generation in confinement, but all adults were released on the date of emergence in Tablón No. 7, Hacienda Santa Rita, where the cane was about two feet high at the time. The white grubs in this field averaged about one per square foot, 4,735 per acre in February–March 1915 and 3,605 in February–March 1916, so there was an abundance of possible hosts present. This field was carefully examined by William Hanson, Jr., when next plowed (February–March 1916) after the release of the wasps, but no *Tiphia* cocoons nor parasitized white grubs were found, either by him or by the laborers collecting the grubs, and it is unlikely that the parasite had become established there.

One other factor contributing to the failure of the parasite introduction was the difficulty of determining the species of *Tiphia* being introduced. It was at first thought that all were of the species *Tiphia inornata* Say., but at least four species occur in central Illinois. The cocoons of *Tiphia illinoiensis* Rob. are small, but those of the commonest species collected, *Tiphia vulgaris* Rob., are indistinguishable from these of the less common *Tiphia clypeata* Rob. and *Tiphia tarda* Say. (Determinations by Mr. S. A. Rohwer.) Nor was it in practise possible to distinguish the species when the adults emerged, as the specific characters, even of dead specimens, are not readily observable, and it was desired to keep all individuals alive and vigorous for breeding or release in the field.

In the summer of 1921, Mr. E. H. Barrow, in charge of the experimental work of Russel & Co., cane growers for Guánica Centrale at Hacienda Santa Rita, found several small black wasps feeding on the secretions of a scale, *Pulvinaria psidii* Mask., on the leaves

of a bush of *palo de muñeca, Rauwolfia nitida,* which were sent to Mr. Rohwer for determination. He wrote to Mr. Barrow (letter of October 21, 1921):

"I have examined them and believe they represent a new species of the genus *Tiphia.* This new species is very similar in many ways to some of the species which Mr. Wolcott introduced into Porto Rico years ago but I believe it is specifically distinct."

FIG. 4.—Adult female of *Elis atriventis* Gahan, a parasite of white grubs. (After Davis.)

Whether these wasps really represent a native species not before collected, or whether they are the descendants of an introduced species, which has varied because of a changed host and environment, and whether they are parasitic on *Lachnosterna* white grubs, and of how great importance they are now, or may become, can only be determined by further study.

In addition to attempting to introduce species of *Tiphia* from the United States, arrangements were made in 1913 for Mr. William Newell, Entomologist in Barbados, to have cocoons of *Tiphia parallela*

Smith collected and sent to Porto Rico. The actual work of collection was done under the supervision of Mr. A. A. Evelyn, who was already having dug up on his estate the cocoons of this wasp for introduction into Mauritius, where the small white grubs of *Phytalus smithi* Arrow, accidentally introduced from Barbados in the soil about potted cane plants, had become a serious pest (4). One hundred cocoons were sent in April 1913, arriving a month later, but only ten adults emerged. No special arrangements had been made

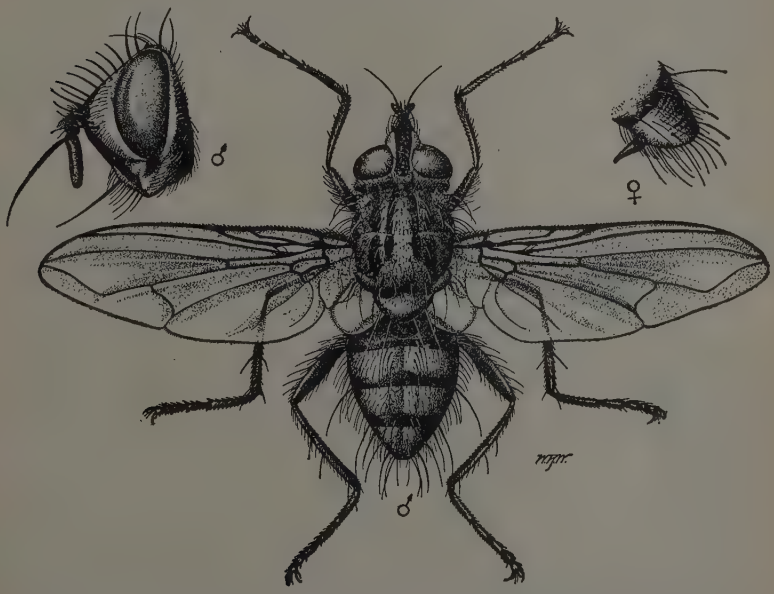

FIG. 5.—Adult male of *Cryptomeigenia aurifacies* Walt., a native Porto Rican parasite of *Lachnosterna* beetles. (After Walton.)

for attempting to have these breed on the grubs of *Phytalus insularis* Smyth, the most nearly related Porto Rican species of grub, and the females did not oviposit on the larger *Lachnosterna* grubs.

Cocoons of *Elis collaris* Say, another wasp parasite of white grubs (Fig. 4.), were collected in considerable abundance in northern Illinois, especially along the Illinois River and near Galesburg, and a few were collected at Plaquemine, La. Few adults emerged from these cocoons in Porto Rico, possibly because they are much more

sensitive to the disturbance by plowing of the soil which closely surrounds them.

There are already present in Porto Rico and native to the Island, two common species of wasps parasitic on white grubs, *Campsomeris dorsata* Fabr. and *Elis haemorrhoidalis* Fabr., and at least four other less common species, *Elis* (*xanthonotus* Rohwer) *erhippum* Fabr., *Campsomeris atrata* Fabr., *C. pyrura* Roh. and *C. trisfasciata* Fabr.

The host of the first of these is known to be the comparatively non-harmful grubs of *Ligyrus tumulosus* Burm., which feed on decaying vegetation in the soil and never on live cane roots, as parasitized grubs of this species collected at Santa Rita produced adults of *Campsomeris dorsata*. The females are large black wasps with two broad, dark reddish-yellow bands on the abdomen, which spend most of their time in the soil and are seldom seen, but the males, which are smaller and less black, having yellow eyes, three narrow yellow bands on the thorax and four large ones on the abdomen, are often seen flying about close to the ground in sandy places, especially in soils where the grubs of *Ligyrus tumulosus* and the pursuing female wasps are present.

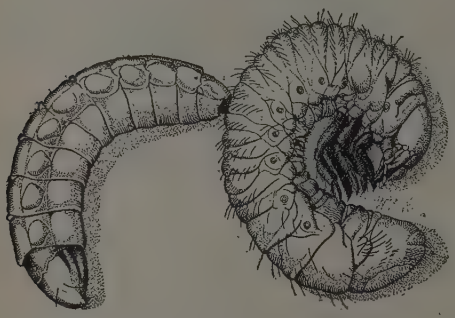

FIG. 6.—Maggot of *Promachus vertebratus* Say, attacking a white grub. (After Davis.)

The host of the second common species, a slender, small black-and-yellow wasp with six narrow bands of yellow on the abdomen, *Elis haemorrhoidalis*, is *Lachnosterna* (*Phytalus*) *insularis* Smyth, the smallest and least injurious of the Lachnosterna group of white grubs, which is found in abundance in sandy soil near the beach, where the very slender male wasps are often seen flying about, or late in the afternoon, resting in clusters of several hundreds on the vegetation. Cocoons of this wasp, with the mandibles of a third-instar grub of *L. insularis* entangled in its outer threads, have been found in a field where no undestroyed grubs of this species were present, but grubs of all instars of *L. citri* were present in abundance and unparasitized.

The wasps of *Elis ephippum* are all black except for a large nearly square reddish-yellow spot on the thorax between the wings. Those of *Campsomeris trifasciata* have, as the specific name implies, three yellow bands on the abdomen and those of *C. pyrura* are larger and have the three abdominal bands more broken. The wasps of *C. atrata* are very large, nearly two inches in length, so large indeed that the white grubs of the Rhinoceros beetles, *Strataegus* spp., seem to be the only host grubs of sufficient size for their complete development, but nothing is known of the life history and host of any of these less common wasps. If any of them are parasitic on the eco-

FIG. 7.—Adult female of *Pyrgota undata* Weid., a parasite of *Lachnosterna* beetles. (After Davis.)

nomic species of white grubs, they are so rare as to be of negligible importance.

Besides the *Scoliid* wasps parasitic on white grubs, there are several other parasites of *Lachnosterna*. A few puparia of an undetermined Tachinid fly, were collected inside dead beetles in plowed fields in Illinois, but no adults emerged from those sent to Porto Rico. There are already present in Porto Rico two species of Tachinid flies, *Cryptomeigenia aurifacies* Walton (Fig. 5.) and *Eutrixoides jonesii* Walton. which are parasitic on the native *Lachnosterna* beetles (5). These flies were first bred from beetles which they had parasitized

and killed, collected near Añasco, but later were found to be moderately abundant thruout the moister portion of the Island. They are not found in the dry sections on the south side where white grubs have caused the greatest damage, and attempts to artificially introduce and propagate them there have been unsuccessful.

Several times, large *Asilid* or robber-fly maggots were found in the plowed fields in Illinois near partly devoured white grubs, for the destruction of which they were apparently responsible. (Fig. 6.) A considerable number of such maggots and puparia were sent to Porto Rico, but as the adult robber flies have the reputation of chasing and killing honey-bees, those emerging were not liberated. They have been identified by Mr. Knab as *Promachus vetebratus* Say. Seven species of *Asilid* flies are reported as occurring in Porto Rico and one species, *Proctacanthus rufiventris* Macq., is quite common.

In some years, large numbers of *Lachnosterna* beetles in Illinois are parasitized by a fly, *Pyrgota undata* Wied. (Fig. 7.), of extraordinary appearance and habits, the females of which lay eggs in the beetles, attacking them when they are flying at night and the ovipositor can be inserted through the unprotected tender skin of the upper part of the abdomen. During the summers of 1913 and 1914, when large numbers of beetles were collected, this fly was comparatively rare and only an occasional parasitized beetle was found. A few flies, all males, were found under electric lights. Several fly puparia inside dead beetles were collected in plowed fields and sent to Porto Rico, but no adults emerged.

The introduction of parasites of *Lachnosterna* had been undertaken so soon after the founding of the "Estación Experimental de la Asociación de Productores de Azúcar de Puerto Rico," because the serious damage caused by the grubs in the cane fields of the south coast, especially near Guánica, demanded prompt action, and as known parasites were supposedly common and had been studied in Illinois, their introduction seemed to promise immediate success. But it was only part of the general plan of Mr. Van Dine that, following the preliminary survey of the sugar cane insect pests of the Island and determining their relative importance, possible methods of artificial control and control by native parasites, the introduction from nearby countries of parasites of all those of economic importance should be undertaken. Trips were made to various sugar cane growing countries, to Mexico in 1912 by Mr. Hood (5), to Demerara, Trinidad

and Barbados in 1913 ([6], [7], [8])and Cuba and Jamaica in 1914 by Mr. Wolcott ([9]), to investigate the presence and abundance of all parasites of insect pests of sugar cane and the possibility of importing the parasites into Porto Rico.

One insect which is nearly always present on sugar cane, and sometimes occurs in very great abundance, is the mealybug, *Pseudococcus calceolariae* Mask. and *P. sacchari* Ckll. It undoubtedly does cause some stunting of the growth of the cane and a resulting loss in tonnage, although its injuries are ordinarily inappreciable, even when the mealybugs are present in such large masses as to prevent the leaf-sheaths trashing off normally. A lady-beetle, *Cryptolaemus montrouzieri* Muls., the larvae of which feed on mealybugs, had been successfully introduced from Australia into Hawaii to prey upon destructive mealybugs, and from there had been successfully introduced and colonized in California. Three shipments of these lady-beetles were made from California to Porto Rico ([10]), and large numbers of them were bred in cages at Río Piedras, Guánica, Fajardo and Mayagüez, feeding them with mealybugs collected from sugar cane. Beetles were released in cane fields at several localities, but none were ever collected in cane fields later. The introduction of this beetle was not a failure, however, except from the standpoint of the cane grower, as the beetles and their larvae have been found feeding on mealybugs and fleshy scales on other plants and trees. and the species is now firmly established in Porto Rico. Mealybugs on sugar cane live under the leaf-sheaths which wrap closely around the cane stalk and protect them from harm and especially from the introduced lady-beetle larvae which are unable to get under the leaf-sheaths, but mealybugs which live on the leaves and branches of other plants are not thus protected and fall an easy prey to *Cryptolaemus.*

In Trinidad there is a lady-beetle, the larvae of which are quite common under sugar cane leaf-sheaths feeding on mealybugs. A small collection of live lady-beetle larvae was sent from there by Mr. Wolcott in 1913, but only one beetle reached Porto Rico alive, as the package was nearly a month in transit. No further efforts were made to introduce it because of the lack of quick and rapid means of transportation.

In Barbados and Demerara the sugar cane mealybugs are preyed upon by the larvae of a lady-beetle, *Hyperaspis trilineata* Muls. ([8]),

which also might be advantageously introduced if the delays of transportation could be overcome. Mr. Bodkin has more recently reported two other species of *Hyperaspis* from Demerara as predaceous on the mealybugs of sugar cane, *H. festiva* Muls. and *H. orthopustulata* Muls. (or *octopustulata* F.) (11).

About fifteen years ago the horn fly, *Haematobia serrata* Desv., became established in Porto Rico, and although now found in all parts of the Island, it becomes most injuriously abundant only in the southern or dryer sections of the Island at the times when there is considerable rainfall. Apparently the abundant rainfall on the north side of the Island renders fresh manure too wet for breeding, and during the periods of least rainfall on the south side the beetles *Aphodius lividus* Oliv. and *Ataenius stercorator* Fabr. become very abundant, and by feeding on and tunneling through the fresh manure change it to a dusty, felty mass of undigested fibers which is also unfavorable for the development of the horn fly maggots. Mr. J. D. Mitchell (12) has observed that in south Texas during very dry weather, "the manure dries before the larvae can pupate, and when the manure is thin, the intense heat cooks the larvae outright."

There are two minute hymenopterous parasites of horn-fly larvae in Porto Rico, a species of *Spalangia* and *Xyalosema bifoveolata* Cress. (determined by Mr. J. C. Crawford) and a small staphylinid beetle *Aleochara* (*anthomyiae* or *nitida*) (determined by Dr. E. A. Schwarz), which is predaceous on them, each of which exerts some influence in reducing the numbers of these flies. During the seasons when the fly is abundant, however, it is a very serious pest of cattle, especially of the bulls and oxen used in plowing and with the cane carts, and arrangements were made by Mr. Van Dine to introduce several species of "tumble-bugs" from various sources to further reduce the amount of manure suitable for the development of the fly maggots. The Egyptian scarab is the prototype of the tumble-bugs, of which a pair, male and female, detatch a bit of manure from a fresh mass, form it into a ball which they roll along the ground and in which the female deposits an egg after they have buried it.

Mr. J. D. Mitchell of Victoria, Texas, sent 275 adult beetles, of which 146 arrived in Porto Rico alive, of three species, *Canthon ebenus* Say., *Canthon laevis* Drury and *Choeridium lecontei* Harold (determined by Dr. W. D. Pierce). About a hundred beetles of *Canthon*

violaceus Oliv. were brought from Santo Domingo by G. B. Merrill ([13]) and 8 adults of *Copris carolina* Linn. were sent by the writer from Randolph, Illinois. These beetles were kept in large outdoor screen cages at Guánica, supplied with fresh cow dung daily and they multiplied rapidly in confinement. When the cages became crowded, a liberation of 100 adults at a time would be made. Although the conditions seemed favorable for these beetles, especially those from south Texas and southern Santo Domingo, yet none were noticed in the field after their release, and it is doubtful if any became permanently established in Porto Rico.

The small success achieved in artificially establishing beneficial insects in Porto Rico has fortunately been paralleled by the difficulty that one serious pest of cattle, the oxwarble, *Hypoderma lineata* DeVill., finds in becoming established here, despite its repeated accidental introduction. Many of these flies have unintentionally been brought in as larvae in the body of the host, their presence unsuspected when the cattle were purchased, but later causing considerable apprehension when the swellings which the maggots cause, appeared on the backs of the cows. No adult flies have been collected, no infested native cattle noted and introduced cattle remain free after the infestation at the time of their importation has been eliminated, indicating a failure of the oxwarble in adjusting itself to the changed environments in Porto Rico and becoming acclimated here.

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THE INFLUENCE OF THE VARIETY OF SUGAR-CANE ON ITS INFESTATION BY *DIATRAEA SACCHARALIS*, AND THE OTHER FACTORS AFFECTING THE ABUNDANCE OF THE MOTH BORER.

By G. N. Wolcott, Entomologist.

The insect doing most damage to sugar cane in Porto Rico is the moth stalk-borer, *Diatraea saccharalis* Fabr. Other insects such as white grubs (*Lachnosterna vandinei* Smyth, *L. portoricensis* Smyth and *Strataegus titanus* Fabr.) and root borers (*Diaprepes spengleri* Linn.) cause more severe and obvious injury in restricted localities, but the moth borer is abundant in cane from all parts of the Island, and its injury is none the less severe because it is less obvious. The injury is caused by the caterpillar, which bores into the young shoots, killing the center and stopping the growth of that shoot, or bores into the stalks, making tunnels which sometimes stunt or kill the top of the cane stalk, but always retard the growth and cause a loss in weight, resulting in a loss of sugar. It has been found by comparative analyses of clean and infested cane "that, on the average, 900 pounds of available sugar is lost for each acre of cane harvested on the south side (of Porto Rico) due to the moth borer"(1), and on the east coast of Porto Rico, the loss "exceeded 670 pounds of sugar per acre" (2). In Louisiana the loss has been estimated at slightly over 1,000 pounds per acre (1,061 lbs., 1,078 lbs. and 1,082 lbs.) (3).

The purpose of this paper is to point out what has been learned about the habits and abundance of the moth borer as affected by the methods of cane cultivation practised in Porto Rico, the varieties grown and, incidentally, by the rainfall. Whether the reduction in borer injury usually resulting from a change in method of cultivation or variety grown is of sufficient importance to justify its adoption, is a problem to be decided by each cane-grower for himself. All changes suggested are recommended solely from the standpoint of reducing borer injury and their adoption in actual field practice will depend upon many other considerations.

There are four stages in the life-cycle of the moth borer, of which the caterpillar is the one most familiar to everybody, as it is in this stage that all the injury is caused. The caterpillar is white or light-

colored, often spotted with black, and when full grown about an inch long. The caterpillar changes to a brown pupa or chrysalis in an enlarged tunnel in the cane stalk, from which a light yellow moth

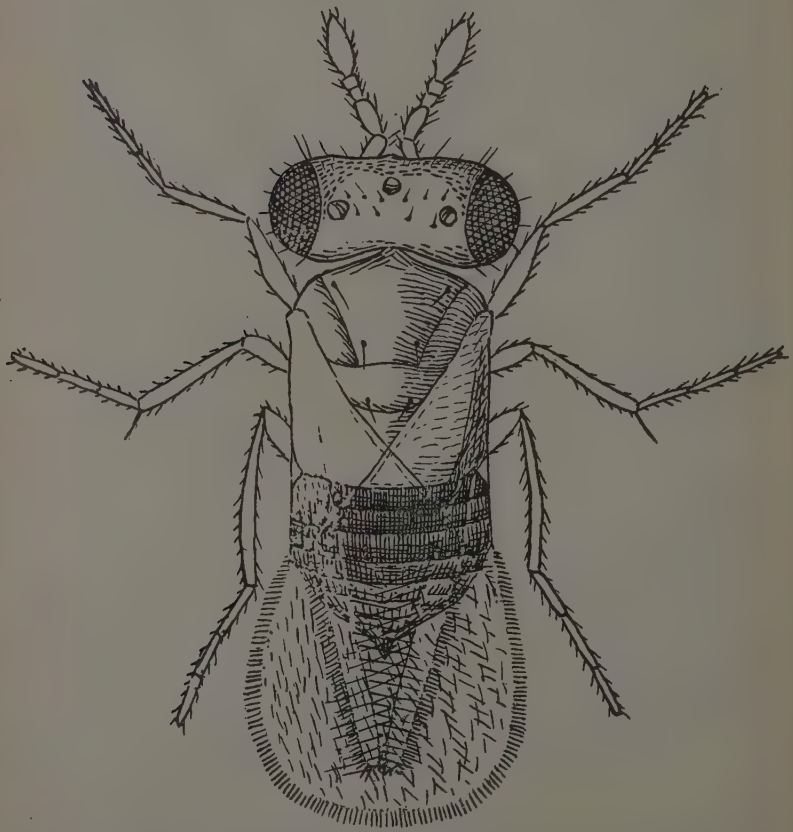

FIG. 8.—*Trichogramma minutum* Riley, the commonest parasite of the eggs of *Diatraea saccharalis*. Enlarged 170 times. (Original.)

emerges a week later. The moths are seldom seen in a cane field as they remain quiet during the day and the female deposits her eggs at night. The flat, creamy eggs occur in clusters of varying

number, laid in rows and overlapping like shingles, on cane leaves. The young caterpillars chew small holes in the leaves or burrow in the midrib, but soon become large enough to burrow into the stalk. Under the mast favorable conditions, the whole life-cycle may be

FIG. 9.—*Prophanurus alecto* Cwfd., a parasite of the eggs of *Diatraea saccharalis*. Enlarged 170 times. (Original.)

completed in twenty-five days, but ordinarily it takes a month or a little longer. Thus in cane which takes twelve months to mature there are the tunnels of at least ten generations of borers, and correspondingly more in older cane.

During the grinding seasons of 1915 and 1916, nearly 50,000 stalks of sugar cane were inspected in all parts of Porto Rico, primarily to determine the abundance of injuries from the borer, and what factors of cultural methods or climate affected its abundance. The results showed that—

(1) In general, the per cent of infestation was inversely proportional to the rainfall; that is, an abundance of rain meant few borers and little rain meant many borers (4).

(2) "In 1915 the infestation by *Diatraea* was 100 per cent higher by localities in fields where the trash was burned and in 1916 it was 50 per cent higher" than in fields where the trash had not been burned (1).

The difference due to rainfall has not been satisfactorily explained, but that due to the burning or non-burning of the trash of the preceeding crop has been credited to its effect on a common egg parasite, *Trichogramma minutum* Riley, (Fig. 8.) of the borer. When a field of trash is burned, many of the adult borer moths and some of the caterpillars in the stalks on the ground or in the stubble will be destroyed, but practically all of the parasites—insignificant little wasps about the size of a pinhead—will be killed. When the young ratoon shoots come up, moths developing from undestroyed larvae in that field, or flying in from other fields of cane being cut, or from cut cane at loading stations, lay their eggs on the young cane leaves, and if all the parasites in that field have been destroyed by burning the trash, young borer caterpillars will develop from these eggs. But if the parasites are present in abundance, the female wasps will oviposit in some or most of the egg clusters and from these more wasp parasites will emerge to destroy succeeding generations of moth-borer eggs.

The little wasps, *Trichogramma minutum*, are one thirty-fifth of an inch long, light yellow in color, except for pink eyes and a darkened base of the abdomen. The wings are transparent, lined and margined with fine hairs, those of the long narrow underwings being very long. Quite recently another egg parasite of *Diatraea* has been found in Porto Rico, *Prophanurus alecto* Crawford, identified by Mr. A. B. Gahan, (Fig. 9.) of about the same size as *Trichogramma,* but all black except for some segments of the antennae and and legs, which are dark yellow. The former parasite is much more common, and has a wide distribution, being found in many tropical and subtropical countries, while the latter, first described from

Demerara, has been found in addition only in some of the Lesser Antilles.

The accompanying illustrations were drawn from live wasps as they appeared under a compound microscope, and are magnified one hundred and seventy times. Because of their minute size, the wasps will never be observed in the field, except possibly when just emerging from a *Diatraea* egg cluster, or when ovipositing in one, but the effects of their presence in abundance will be apparent in lessened damage to the sugar cane by the borers.

However, the burning or non-burning of trash in some sections of the Island, especially along the south coast between Fortuna and Arroyo, seemed to have little or no effect on the moth-borer. Many field men, who were present while counts of the borer injuries in their cane were being made, have suggested that the variety of cane had something to do with its infestation by the borer. The following is the average infestation of the various varieties of sugar cane:

18 per cent Cavengirie,
23 per cent Yellow Caledonia,
30 per cent Rayada,
34 per cent B–3412,
34 per cent other Demerara varieties,
47 per cent Otaheite or Caña Blanca,
49 per cent other Barbados varieties,
52 per cent Crystalina,
56 per cent Guánica varieties,
61 per cent D–117.

But this does not tell the whole story. The distribution of the different varieties is very uneven in various parts of Porto Rico, some being grown only in the dry sections and others only in the wet. As the percentage of infestation is affected by the amount of rainfall and by the burning or non-burning of trash, the separation of the data under these headings gives a fairer standard of comparison. (See page 26.)

Also, many, if not most, of the cane fields in Porto Rico contain a mixture of two or more varieties. When more than two varieties were present, the record was discarded as useless in preparing the table, but when only two are present, half credit is given for that examination to each of the two varieties. The average of the mixed cane often differed considerably from that of the average of the variety, but usually so as to show a more sharp contrast between the environments. This is the case in the figures for Crystalina in

PER CENT OF SUGAR CANE IN PORTO RICO (1915 AND 1916) INFESTED BY THE MOTH STALK-BORER, *DIATRAEA SACCHARALIS*, AS INFLUENCED BY (1) RAINFALL, UNDER 50 INCHES OR OVER 50 INCHES, (2) BURNING OF TRASH OF PRECEDING CROP, YES OR NO, AND (3) VARIETY OF CANE.

Rainfall		Under 50 inches.		Over 50 inches.	
Trash burned		Yes.	No.	Yes.	No.
Average.	Variety.				
47 per cent	Otaheite or Caña Blanca	61 per cent (46 fields, 15 mixed.)	34 per cent (9 fields, 4 mixed.)	50 per cent (9 fields, 5 mixed.)	28 per cent. (36 fields, 25 mixed.)
30 per cent	Rayada	62 per cent (4 fields, 2 mixed.)	28 per cent (7 fields, 5 mixed.)	37 per cent (42 fields, 12 mixed.)	26 per cent. (114 fields, 54 mixed.)
52 per cent	Crystalina	62 per cent (48 fields, 2 mixed.)	56 per cent (21 fields, 1 mixed.)	75 per cent (2 mixed fields.)	13 per cent. (6 fields, 5 mixed.)
23 per cent	Yellow Caledonia			25 per cent (10 fields.)	22 per cent. (16 fields.)
18 per cent	Cavengerie				18 per cent. (9 fields.)
34 per cent	B–3412	40 per cent (14 fields.)			
49 per cent	Other Barbados varieties	72 per cent (10 fields.)		32 per cent (3 fields.)	34 per cent. (9 fields.)
61 per cent	D–117	71 per cent (13 fields.)			36 per cent. (4 fields.)
34 per cent	Other Demerara varieties		80 per cent (2 fields.)		16 per cent. (5 fields.)
56 per cent	Guánica varieties	66 per cent (146 fields.)	34 per cent (2 fields.)		
	Average of all varieties	60 per cent (146 fields.)	46 per cent (47 fields.)	37 per cent (68 fields.)	24 per cent. (200 fields.)

NOTE.—Under each percentage is given the number of fields examined in obtaining that percentage, both unmixed and mixed, followed by the number of mixed fields.

the fields of abundant rainfall, but not too much weight should be given these records when over half are from mixed cane.

Also, little weight should be attached to records obtained by the examination of only a few fields (and those from only one field under a heading have purposely been omitted), but records from more than ten fields, when less than half are of mixed cane, may be considered as being a true record of average conditions for that variety and environment. Unfortunately the data is lacking for making comparisons of many varieties under all conditions and is insufficient for reaching definite and final conclusions on many points. But the considerable amount of data on some varieties and under some environments make it possible to state that (at least in 1915 and 1916) in Porto Rico—

(1) Crystalina in the dry sections and Yellow Caledonia in the moist sections are only slightly affected by the burning or non-burning of the trash, but Otaheite and Rayada in all comparable sections of the Island are nearly (or over) twice as heavily infested where the trash has been burned, and, if much confidence may be placed in an average of two observations, this is also true of the Guánica varieties.

(2) The canes most commonly grown in Porto Rico, Otaheite, Rayada and Cristalina, are equally infested in trash-burned fields of the dry sections of the Island. B–3412 has an apparently lower infestation, but as this variety has a thin stalk, probably has as many borers per acre or per ton as the other common varieties, but compares most favorably with D–117 and the other Barbados, Demerara and Guánica seedling varieties.

(3) Rayada is somewhat less attacked by borer under other conditions than is Otaheite.

(4) Yellow Caledonia and Cavengirie, despite the long season (18 months) necessary for them to reach maturity, have the lowest infestation of any canes grown in the moister sections of the Island. In this connection it should be noted that B–3412, which has the lowest infestation per stalk in the dry section of the Island, is also a long-season cane.

The characteristic of these varieties which is responsible for the difference in borer infestation is not at once apparent. Yellow Caledonia, Cavengirie and B–3412 are long-season canes with low sucrose content until they mature, while Crystalina has considerable sugar even when immature, and this checks up fairly well with the

data at hand. But D–117, with only a slightly shorter season than B–3412, is nearly twice as heavily infested. The hardness of rind, or high percentage of fiber and difficulty of milling, which is also characteristic of the canes with low borer infestation, would seem to be more the sort of thing that would affect an insect that chews and bores into their stalks, but Otaheite, the easiest milling cane, does not have the highest borer infestation. B–3412 and D–117 have very nearly the same amount of fiber. Although the borer may live and complete its development in the older and harder portion of the cane, the majority of the caterpillars live in the young shoots or in the younger growing top of the older cane, which is soft and comparatively easily bored in all varieties. It is quite possible that the varying degrees of the acidity or possible esters of the cane juice, as affected by variety and rainfall, in these growing portions of the cane, is the determining factor favoring or retarding its development, but no data is available for judging of this.

Whatever may be the cause of the difference in infestation of the varieties, its practical importance to the cane-grower is that when it is practicable to grow Yellow Caledonia and Cavengirie, and possibly B–3412, borer infestation is automatically reduced.

Mr. R. A. Veve, of the Experiment Station of the Fajardo Sugar Company, in 1919–20 and 1920–21, made counts of *Diatraea* infestation in a considerable number of varieties of cane grown in Haciendas Santa Rita, Santa María and San Pedro, where the rainfall was abundant, and usually where the trash had not been burned. The averages of all his counts of some varieties is as follows:

D 116, 32 per cent infested (2 counts).
Rayada, 31 per cent infested (8 counts).
Otaheite, 30 per cent infested (2 counts).
D 109, 27 per cent infested (3 counts).
D 117, 21 per cent infested (3 counts).
D 433, 21 per cent infested (11 counts.)
Y. C., 16 per cent infested (4 counts).
Cavengirie, 8 per cent infested (1 count).

There is one point in the habits of the moth borer that renders it possible to somewhat reduce its numbers in young plant cane. The moths can not emerge from their pupal stage if the cane is buried under the soil, but have no difficulty in emerging from discarded seed left on the banks or in the *callejones* where the seed is recut and reselected for planting. All seed containing borer caterpillars, or showing their injury, SHOULD BE PLANTED, as this does not cause

the young shoots to be infested, and ordinarily germination is just as good from such seed (1), and sometimes better, because the borer has stunted growth and caused the production of more eyes. Or if such seed is discarded, it should be BURIED. Burning is not effective as the seed will not burn while green and if delayed until dry enough to burn, most of the moths will have emerged. By the proper care of infested seed, either planting or burying it, one source of infestation of young plant cane is eliminated.

But the prevention of the emergence of the moths from infested seed may have no apparent effect, as there are other sources of infection. The grinding of the cane at the mill destroys large numbers of borers, probably the majority present in the cane, but from the beginning of cutting until the cane is ground—until ALL of it is ground—it constitutes a constant menace and source of infection for all nearby fields.

Usually young plant cane has other fields of cane in various stages of growth on from one to all sides of it and adult female moths will fly in from these adjacent fields, especially when they are disturbed when the cane is being cut. The only way of obviating this would be to begin harvesting at one end of a property, preferably beginning to the windward, or in the fields farthest away from the mill and cutting towards the mill, and cut all cane in regular sequence until the other end is reached, planting no cane until all the cane from surrounding fields is harvested.

Often when cane is being cut, the poorest stalks will be left in the field and not taken to the mill to be ground. The stalks may be poor because of disease, or because the rats have chewed them, but the usual reason why they are poor and not worth harvesting is because they have been injured by the borer. The adult moths have often not emerged from this cane at the time it is cut, and if it is left in the field they will be able to lay their eggs on the young ratoon shoots. Burning the trash does not kill all the borer larvae in stalks on the ground, although it does kill some, and is largely ineffective in its immediate consequences and positively harmful eventually in borer control. All cane should be sent to the mill to be ground, as this is the only sure way of destroying the borers and other harmful insects in it.

Occassionally borers are found in stubble after the cane has been cut, but this is comparatively rare as the borers usually live in the

younger parts of the cane stalk, and practically never occurs if the stalks are cut close to, or slightly below, the surface of the ground.

There is one other important source of infection and that is the cut cane deposited at loading stations, or in the cars here or en route to the mill, or in the *batey* at the mill. On the leaves of the young plants of plant or ratoon cane adjacent to a loading station or the railroad sidings where loaded cane cars are stored, egg clusters of the borer will usually be found in abundance, due to the moths which have emerged from the cane before it reached the mill and flown to the nearest cane field. There is no way of avoiding this source of infestation after the loading station is located and built, and ordinarily there is every other reason in favor of having it as near as possible to the fields where the cane is cut. When the mill, however, is located outside the cane-growing district (as Guánica Centrale and Central Aguirre), moths emerging from the cane in the cars stored in the *batey* ordinarily perish before they are able to fly to the nearest cane field and lay their eggs. It is sometimes possible to have the fields around the mill or along the switches where the loaded cane cars are temporarily stored, in pasture rather than in cane. This is by no means a minor source of infection, as an example will show. Suppose stalks of cane average four pounds each (which is low for Yellow Caledonia, but somewhat high for most other varieties), then one ton contains 500 stalks, of which, if fifty per cent are infested with the borer—which is a fair average for Porto Rico—and one-tenth contain live borers (there being about ten generations of the borer in twelve months, the minimum growing period for cane), then there are twenty-five live borers in one ton of cane. Every day one of these borers will be ready to emerge as an adult moth, so that for each day that a loaded twenty ton cane car remains near a cane field, ten male and ten female moths will emerge and fly into the adjacent fields. As the cane at a loading station is constantly renewed, there is a constant stream of moths emerging from it and flying to the nearby cane, even though no cane is there for an extended period.

If the little wasp egg parasites (*Trichogramma minutum*) are present in abundance in a field, they will destroy some of the borer egg clusters resulting from the moths reaching the field from sources of infection which cannot be eliminated, but this again emphasises the importance of not burning the trash. Burning the trash destroys

most of these beneficial little insects, as they can not fly far and escape the destruction of a cane fire.

Non-burning of trash, to favor the egg parasites, growing of varieties resistance to borer attack, such as Yellow Caledonia, Cavengirie, and B–3412, and care in burying infested seed and cleaning up infested cane and sending it to the mill as soon as possible, will reduce injury by the moth stalk-borer of sugar cane, *Diatraea saccharalis.*

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THE INSECTS OF SUGAR CANE IN SANTO DOMINGO.

By GEORGE N. WOLCOTT, Entomologist.

The only published record of the insects of sugar-cane in Santo Domingo is a "Report of the Entomologist's Inspection Trip to Santo Domingo" by W. V. Tower (1). In the files of the Insular Experiment Station, Río Piedras, Porto Rico are: (1) a supplementary report giving the determinations by specialists of the U. S. National Museum of the insects he collected, (2) a copy of the letter from C. B. Goucaux and H. Bourne to Mr. Van Alan Harris, administrator, Central Romana, La Romana, R. D., detailing their investigations at Higüeral on the Santo Domingo cane butterfly, incorrectly given as *Calisto archebates* Men., supplemented by (3) a determination sheet of the insects they collected, and (4) an extract from the diary of E. G. Smyth for the period when he was at Higüeral, collecting cane insects and working on the cane butterfly.

The author for five months was Entomologist at Estación Agronómica, Haina, R. D., but had little opportunity to observe the insects of sugar cane, except in the immediate vicinity of Haina. Nevertheless, additional observations were made at San Pedro de Macorís when returning to Porto Rico, which combined with the unpublished data, made possible the compiling of a list of insects of sugar cane in Santo Domingo, modeled on those of D. L. Van Dine in Porto Rico (2), G. E. Bodkin in Demerara (3) and T. E. Holloway and U. C. Loftin in the United States (4). The insects marked with a star are also found in Porto Rico and many of the less important are more fully treated in recent publications by E. G. Smyth (5) and by the author (6). Thanks are due to the various specialists for determinations. When no authority is given, the determination is by the author.

A LIST OF THE INSECTS OF SUGAR CANE IN SANTO DOMINGO.

THYSANURA.

No. 1*.—A green springtail, common on the underside of leaves.
No. 2*.—A grey springtail, common under dead leafsheaths on the stalk.

Determinations not yet received from Prof. J. A. Folsom.

ORTHOPTERA.

No. 3*.—*Schistocera pallens* Thunbg. A large brown grasshopper, not common.

No. 4*.—*Neoconocephalus triops macropterus* Redt. and *fuscostriatus* Redt. A large all green or all grey or all brown grasshopper.

Determined by A. N. Caudell. Eggs are deposited under the green leafsheaths. Both nymphs and adults feed on leaves and are found hiding in the central whorl.

No. 5*.—*Conocephalus cinereus* Thunbg. Determined by A. N. Caudell. A small light-green grasshopper, with median dorsal brown stripe, not common on cane, more often feeds on coarse grass.

No. 6*.—*Grillus assimilis* Fabr. Determined by A. N. Caudell. A large cricket attacking young seedlings.

HEMIPTERA-HETEROPTERA.

No. 7*.—*Lasiochilus divisus* Champ. (P. R. specimens determined by E. H. Gibson). A small brown Acanthiid bug, nymphs pinkish brown, common under leafsheaths, probably predaceous.

No. 8*.—*Blissus leucopterus* Say. The Chinch bug. Nymphs occassionally found in "dead-hearts," or on young shoots otherwise injured. All stages common on corn and rice.

HEMIPTERA-HOMOPTERA.

No. 9*.—*Kolla (Tettigonia) similis* Walk. (Determined as *Tettigonia* sp. near *anita* Fowl. and near *prolixa* Fowl. by O. Heideman for W. V. Tower) The West Indian Sugar-Cane Leafhopper. A large bright-green leafhopper with inconspicuous black markings and black underwings. All stages common on young plant cane. Adults have been found with one or two red mites attached.

No. 10.—*Catonia intricata* Uhler. Determined by W. L. McAtee. A mottled brown Fulgorid, not abundant, immature stages not observed.

No. 11.—*Lamenia inflata?* Ball. Determined by O. Heideman for W. V. Tower.

No. 12*.—*Saccharosydne (Delphax* or *Stenocranus) saccharivora* Westw. The West Indian Cane Fly. A Niagara green, transparent winged Fulgorid. Common, heavily parasitized, especially in the egg stage.

No. 13*.—*Sipha flava* Forbes. The Yellow Aphis of Sugar Cane. Common on the underside of the older leaves of young shoots. The ladybird beetles, *Cycloneda sanguinea* Linn.

and *Hyperaspis apicalis* Weise, determined by E. A. Schwarz, found by W. V. Tower on sugar cane, are probably predaceous on this aphid.

No. 14.—*Pseudococcus bonïnsis* Kuwana. Determined by H. Morrison. A grey mealybug, on stalks not covered by leafsheats.

No. 15*.—*Pseudococcus* sp. prob. *calceolariae* Mask. A pink mealybug, on stalks under leafsheaths. Attended by *Solenopsis geminata* Fabr. and *Prenelopsis longicornis* Latr., determined by Dr. W. L. Mann.

LEPIDOPTERA.

No. 16.—Pyralid with leaf-rolling larva, brown head, creamy opalescent body, not bred to adult. Common in young cane, tying together the leaves of the central whorl.

No. 17*.—*Diatraea* prob. *saccharalis* Fabr. The Moth Stalk-Borer of Sugar Cane. Common. Larvae not bred to adult.

No. 18*.—*Laphygma frugiperda* S. & A. The light-green form of larva common in young cane. Not bred to adult.

No. 19.—*Helophila subpunctata* Harvey. Reported from Higueral by Goueaux & Bourne and Smyth. Larvae killed by a fungus.

No. 20*.—*Prenes ares* Felder. Determined by H. G. Dyar. Fairly common. The larvae are bluish-grey green, with broad black collar above on posterior half of first segment. The head is yellow with brown median and lateral markings, the true legs and first spiracle black. Pupates in a loose cocoon in cane leaves to a creamy to light yellow blunt-ended chrysalis, head hairy, dark brown and with brown crescents on eyes and brown spots and dots dorsally. Adults brown, with largest yellow spot on forewing an irregular paralellogram. The larvae also feed on rice. Parasitized by *Apanteles disputabilis* Ashm., determined by C. F. W. Muesebeck

No. 21*.—*Prenes nero* Fabr. Determined by H. G. Dyar. More common on cane than *P. ares*. Larva all yellowish green. Chrysalis semitransparent green, with four light yellow stripes dorsally and a horn on the head, suspended in silken girdle in cane leaf. Adult brown, with largest yellow spot on forewing triangular.

No. 22.—*Catia misera* Lucas. Determined by H. G. Dyar. The smallest and most common Hesperid larva feeding on cane leaves, also common on rice and other coarse-leaved grasses. Larvae are green with purplish-brown head, variably marked with silvery or greenish yellow. Chrysalis much smaller, but similar in appearance to that of

Prenes nero. Adult usually all brown, or with a few small yellow or light spots on wings, body slender.

No. 23*.—*Perichares corydon* Fabr. Determined by H. G. Dyar. The largest and rarest Herperid. Larva yellowish green, noticeably pubescent with many long fine white hairs. True legs and head black in earlier instars. Head all green or marked with black (giving a dirty appearance underneath the pubesence) in last instar. Chrysalis large, similar in appearance to that of *Presnes nero* but darker green, with proboscis tube extending beyond caudum and with only two bright yellow stripes on dorsum. Adult is brown, with chestnut eyes, forewings each with four yellow spots and light brown crescent, all marked with lavender underneath.

No. 24.—*Calisto pulchella* Lathy. Determined by H. G. Dyar. The Santo Domingo Cane Butterfly. Dr. Dyar writing (apparently to Dr. L. O. Howard, Chief of the U. S. Bureau of Entomology) of the larvae and adults collected by W. V. Tower, says:

> "*Calisto* of two species, apparently *zangis* Fabr. and *archebates* Men., but in bad condition. I am interested in Mr. Tower's discovery of the larva of *Calisto.* This seems to be a new enemy of sugar cane and will naturally be one only in the West Indies as the *Calisto* butterflies are confined to that region. I hope Mr. Tower will pursue the subject and secure a lot of good specimens of the butterflies, so I can make sure of the names."

(*Calisto zangis* occurs in Porto Rico but the larva has not been found feeding on sugar cane).

A few adults bred from larvae collected on cane by the author at San Isidro, R. D. (a short distance east of Santo Domingo City) were determined by Dr. Dyar, who reports them as *C. pulchella* Lathy. An abundance of adults collected by E. G. Smyth at Higueral in 1914 has recently been sent to Dr. Dyar, who reports a few as *Calisto hysius* Godt. but the great majority as *C. pulchella. Calisto pulchella* is undoubtedly the correct name for the economic species.

Very common Satyrid butterflies, especially at Higueral in December and January and at San Pedro de Macoris. The grey-brown mottled larvae hide in the central whorl, usually of large cane, eating the edges of the leaves, sometimes leaving nothing but the midribs. They pupate under old loose leafsheaths hanging to the stalks. Pupae are mottled brown and are parasitized by *Chalcis annulata* Fabr., determined by J. C. Crawford. The large brown butterflies, reddish on the hind wings, feed on the

juice of cane discarded after being chewed by peons, and at mud-puddles.

DIPTERA.

No. 25.—*Hippelates flavipes* Loew. Determined by J. M. Aldrich. "Mimis." Small black flies common on young cane, causing no apparent injury, the larvae of which possibly breed in cane trash. The flies are annoying to man and animals.

COLEOPTERA.

All determinations by E. A. Schwarz.

No. 26.—*Hololepta quadridentata* Fabr. A flat shining black Histerid beetle, predaceous or scavenger in injured cane stalks. Recorded by Smyth as usually found in the hold of boats bringing cane from Higueral for grinding in Porto Rico.

No. 27.—*Chaetocnema* prob. *minuta* Melsh. (Determined as *C. apricaria* for W. V. Tower). Small black flea-beetles, common on leaves of young cane. Feeding holes not observed. The larvae may feed on cane roots.

No. 28.—*Diaprepes quadrivittatus* Olivier. The Santo Domingo Weevil Root Borer. A large black beetle with four yellow or pink stripes on elytra. Adults feed on leaves of *Inga vera* and other plants, grubs bore into cane roots.

No. 29*.—*Diaprepes spengleri comma* Boheman. A variety of the common Weevil Root Borer of Porto Rico.

No. 30.—*Metamasius sericeus* Olivier. The Weevil Stalk Borer of Sugar Cane in the West Indies. The most obvious difference between this species and *M. hemipterus* Linn. of Porto Rico is in the coloration of the posterior two-thirds of the elytra, that of *M. sericeus* being black and that of *M. hemipterus* streaked with reddish-brown, tho in general appearance and habits the two species are quite similar. Recorded by Tower, Smyth and Goueaux & Bourne at Higueral.

No. 31.—Hunter No. 3974. Calandrid. "Nothing similar to it in the National Museum collection." E. A. Schwarz. Small larvae causing "dead hearts" in young plant cane, common near San Isidro. One adult bred, crippled and immature.

No. 32.—*Xyleborus* sp. Shot-hole Borer. Reported by Tower at Higueral.

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THE CATERPILLARS WHICH EAT THE LEAVES OF SUGAR CANE IN PORTO RICO.[1]

By THOS. H. JONES, former Entomologist, and GEORGE N. WOLCOTT, Entomologist.

Seven species of lepidopterous larvae are known to feed on the leaves of sugar cane in Porto Rico. Four of these, *Prenes nero* Fabr., *Prenes ares* Feld, *Atrytone vittelius* Fabr., and *Perichares corydon* Fabr., are caterpillars which have the first segment of the body much constricted, giving the appearance of a narrow neck and a large head. The adults of these four species are skipper butterflies of the family Hesperidae.

The other three species are *Cirphis* (*Heliophila*) *latiuscula* H. S., *Laphygma frugiperda* S. & A., and *Remigia* (*Mocis*) *repanda* Fabr., the adults of which are moths belonging to the famliy Noctuidae.

With the exception of *Prenes nero,* the larvae of the skipper butterflies have never been noted to be sufficiently abundant to be important pests of sugar cane in Porto Rico. The caterpillars of two of the noctuid moths, *Laphygma frugiperda* and *Remigia repanda,* do at times, however, occur in destructive numbers. This is especially true of *Laphygma frugiperda.* Although it is heavily parasitized its eggs are laid in large clusters and, if a few clusters in one part of a field are unparasitized, they may produce enough caterpillars to entirely defoliate the cane or *malojillo* grass before they are destroyed by the larval parasites.

Six of the species of lepidopterous larvae mentioned are discussed on the following pages. The information so far obtained concerning the large skipper, *Perichares corydon,* the larvae of which occasion-

[1] This paper was left by Mr. Jones marked "Not completed" when he resigned in September 1914. It was to complete the publications on the more important pests of sugar cane in Porto Rico, of which the others are: (1) Aphids or Plant-Lice attacking Sugar Cane in Porto Rico, Bul. No. 11, (2) The Sugar-Cane Moth Stalk-Borer, *Diatraea saccharalis,* Bul. No. 12, (3) The Sugar-Cane Weevil Root Borer, *Diaprepes spengleri,* Bul. No. 14, all by Mr. Jones, and the papers by Mr. E. G. Smyth on the white grubs injuring sugar cane in Porto Rico. It has been finished by the junior author.

Dr. L. O. Howard, Chief of the U. S. Bureau of Entomology, very kindly authorized the use of the cuts illustrating the portion of this article dealing with *Laphygma frugiperda,* the other drawings having been made by the senior author. To the various specialists in the Bureau of Entomology or in the National Museum who identified specimens, the authors are greatly indebted: to Dr. Harrison G. Dyar, who identified the *Lepidoptera,* to Dr. J. M. Aldrich or Mr. W. R. Walton, who identified or named and described the *Diptera,* and to Mr. S. A. Rowher, Dr. C. F. W. Muesebeck, Mr. A. B. Gahan and Mr. A. A. Girault, who determined the *Hymenoptera.*

ally feed on cane, is not sufficient to warrant the inclusion of an account concerning it.

Prenes nero Fabr.

Larvae of this skipper have been found feeding upon the leaves

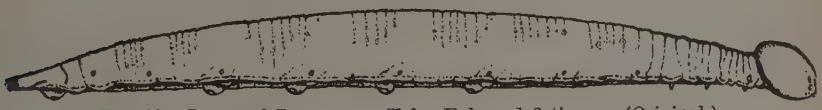

FIG. 10.—Larva of *Prenes nero* Fabr. Enlarged 2 times. (Original.)

of sugar cane, rice, bamboo, *malojillo* grass, and Johnson grass. They are more common during the fall and winter months, when a few individuals are often found in fields of young cane.

The eggs are hemispherical, about 1.8 mm. in diameter, and are laid singly on leaves of cane. When first laid they are nearly white, becoming grey with age, often with a rosy tinge, and with the apex and a circle about and just below it darkest. Under a lens, the entire curved surface shows delicate reticulations, hexagonal in shape. The eggs hatch in four or five days into caterpillars about 2 mm. long, light grey except for a large black head, which devour the free portion of the egg shell, leaving the attached base. Their bodies become green as they feed on the leaves of the host plant. After the first molt the head is green with two narrow purplish lines extending down over each eye, but in later instars these lines disappear. Four light longitudinal dorsal lines appear on the body with the first molt and remain constant.

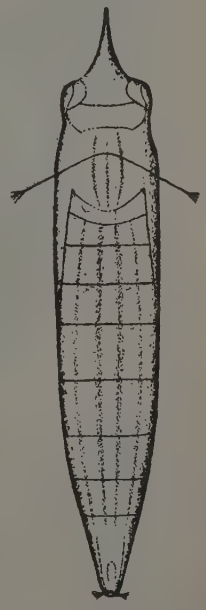

FIG. 11.—Chrysalis of *Prenes nero* Fabr. Enlarged 2 times. (Original.)

The mature larva (Fig. 10.) is light green closely approximating the color of the underside of healthy cane leaves. On closer inspection the surface is seen to be marked with pale, chrome yellow, transverse lines near the intersections of the segments, and four, light, longitudinal, dorsal lines. All markings are more distinct at either end of the body. There are also numerous, very small, darker green dots and sparse short hairs. Below, the body is bluish green and laterally

a white line extends along a slight fold just below the level of the stigmata.

The caterpillars, even while quite young, eat entirely through the leaf blade, beginning at the outer edge. During the day the larva rests in a shelter made by drawing together the edges of the leaf with a couple of silk bands, where it later pupates. One larva reared in the laboratory pupated after thirty days, having molted four or five times.

The chrysalis (Fig. 11.) rests on a film of silvery silk, its ventral surface next the leaf, and is held in place by a band of silk over the

FIG. 12.—Adult of *Prenes nero* Fabr. Enlarged 2 times. (Original.)

thorax and by several strands at the anus. It is translucent, light green, with a number of slightly wavy light lines extending lengthwise dorsally. Four extend the full length of the thorax and abdomen, converging at either end, and one on each side, laterally, follows the line of the stigmata. Ventrally, especially the wing-pads and undeveloped legs, and at either attenuated end, the pupa is more opalescent and less green. On the head projects a curved, conical tubercle or horn. The pupa is about 30 mm. long and 5 mm. wide. A day or two before it issues, the eyes of the butterfly in the chrysalis become bright pink. Later the entire pupa becomes dark purplish. The pupal period required ten or twelve days in those individuals kept under observation.

The adult (Fig. 12.) is a dark brown, thick-bodied butterfly, with wings darker above than below and the ventral surface of the body nearly white. Of the seven, or less, white, semi-transparent spots on each of the forewings, the largest is acutely triangular. The wing spread of the largest adults is 35 mm.

The larvae of this skipper, the most abundant of any found in cane fields, are parasitized by two species of hymenopterous insects. The larvae of one *Ardalus antillarum* Gahan, issue from the caterpillars and form naked black pupae nearby, sixteen individuals having been observed to come from one large larva. The larvae of the other, *Apantales prenidis* Mues., spin white cocoons like grains of rice above the empty caterpillar skin. A female wasp, *Polistes crinitus* Felton, was observed to bite into and suck the juices from a pupa which she had discovered.

The most important enemy of the species in an egg parasite, *Trichogramma minutum* Riley; a minute, light-yellow wasp, adults of which issued from over two-thirds of the eggs of the butterfly found in the field. From seven to eleven individuals have been observed to emerge through a small hole in the side of an egg. This and the other parasites are so effective in keeping down the numbers of *Prenes nero* that artificial means of control need not be considered.

Prenes ares Felder.

The larvae of this skipper, which are even less abundant in cane fields than those of *Prenes nero*, have also been found on a number of other coarse-leaved grasses common in Porto Rico.

Fig. 13.—Lateral view of head and thorax of *Prenes ares* Felder. Enlarged 2 times. (Original.)

The hemispherical, light-green or yellow eggs are laid singly. The measure about 1.5 mm. in diameter and are delicately reticulated; the reticulations near the apex being hexagonal and those towards the base linear. They hatch in three or four days, turning silvery grey just before hatching.

Fig. 14.—Cephalic view of head of larva of *Prenes ares* Felder. Enlarged 2 times. (Original.)

The young larva is transparent yellow, becoming light-green after feeding, with a large black head and with a black line, appearing from above like a collar, on the dorsal part of the first segment of the body and extending on either side to the spiracle. The caterpillar, as it emerges from the egg, is about 4 mm. long and sparsely

covered with stiff black hairs which disappear after the first molt. The fully grown larva is of a bluish grey green, with true legs black at tip and ringed with black, and a black collar on the dorsal posterior portion of the first segment, ending in lateral enlargements at the spiracles (Fig. 13.) The spiracles of this segment are black; the others are of the same color as the body and scarcely distinguishable. The head (Fig. 14.) is brown with median and lateral markings of yellow, sometimes covering a larger area than the brown portion. The largest larva observed was 38 mm. long.

FIG. 15.—Chrysalis of *Prenes ares* Felder. Enlarged 2 times. (Original.)

The caterpillar feeds at night, eating the edges of the leaves, and rests during the day in a shelter made by pulling together two or three leaves at their tips and holding them in place with silk. In this shelter a thin cocoon of white silk is spun, in which the larva pupates.

The chrysalis (Fig. 15.) is light yellow, with creamy opalescent wingpads, and is covered with light yellow hairs. The head is specially hairy, dark-brown above, with brown crescents on the eyes. There are two large brown spots and several pairs of smaller ones on the thorax. The proboscis tube is free, extending to the middle of the 11th segment. The chrysalis is about 27 mm. long. Adults have emerged on the ningth or tenth day after the pupa was formed.

The adult is dark-brown, thick-bodied, butterfly, differing most markedly from that of *Prenes nero* by having the largest white spot on the forewings irregularly rectangular. Beneath, the wings are marked with light, bluish-white, irregular bands. The wing spread is about 35 mm.

The eggs of *Prenes ares* are parasitized by *Trichogramma minutum,* thirty-two adults having emerged from one egg. There are at least two small Ichneumonid parasites of the larva, *Apantales prenedis* Mues., which is black and *Microbracon* sp. which is yellowish brown.

Atrytone vittelius Fabr.

The larva of this small skipper feeds on older cane leaves and has twice been quite common at Río Piedras.

The eggs are hemispherical, about 1.3 mm. in diameter, grey be-

low, darker towards the apex, and marked with hexagonal reticulations.

The larva when first hatched are light grey-green, so transparent that their internal organs are plainly visible, but becoming green and more opaque as they begin to feed. On the first segment there is a dorsal black band, terminating laterally just above a black dot, and the head is black, becoming lighter brown, lined with black, in the later instars. Fully grown caterpillars are 35 mm. long. The general color of the body is robin's egg blue, but looked at more closely is seen to consist of a lighter-colored network surrounding numerous darker spots subtending small hairs. There is a darker medio-dorsal stripe, and the three anterior and the posterior segments are somewhat more yellow-green than blue. The spiracles are yellow, and the true legs are also opalescent light yellow. On the dorsal half of the first segment is a black half-ring ending on each side just above a large black spot. The head is roughly granular, dull yellow, black where attached to the neck, around the outer edge and in front in two broad straight vertical lines.

The larvae feed at night, resting by day in shelters of partly-eaten, folded-over leaves, held together with numerous strands of silk, in which, after filling in the open ends with more silken strands, the chrysalis is formed. The chrysalis is 18.5 mm. long by 3.5 mm. wide, opalescent creamy yellow on the wings, lighter on the abdomen, but a dull light red on the head, which also has many straight hairs, the rest of the pupa being faintly pubescent. The general appearance of the chrysalis is similar to that of *Prenes ares,* but smaller and unmarked.

The adult is a small butterfly, with brilliant, shining, chrome yellow wings, margined with black, having an expanse of about 27 mm.

Cirphis (Heliophila) latiuscula H. S.

This is the least important of the noctuids whose larvae feed on cane leaves in Porto Rico, largely because the caterpillars feed on the leaves of large and mature cane and usually occur singly. They usually feed on the edges of the leaves, and are found in the daytime resting far down in the central whorl of leaves. The eggs have not been found. The caterpillars, though of similar appearance, vary considerably in color. Many are light greenish grey, with numerous lines extending along the back and sides; the head being

light brown and the spiracles black. Some are more yellowish and others browner, and others are somewhat pinkish, especially between the segments. All larvae have a smooth appearance, the smaller ones being generally lighter in color and more translucent. The full-grown larvae are about 40 mm. long.

The pupa is formed in a loosely constructed cocoon in old leaf-sheaths or in trash adhering to the stalk or on the ground. It is dark-reddish brown, smooth and polished, and about 19 mm. long. The pupal period is from two to three weeks.

The cream-colored adults have a wing expanse of about 35 mm. The body is cream colored, the forewings light grey and the hind wings glistening white, bordered with grey. The front wings are speckled with two rows of black points, one close to the outer margin, the other, of larger and more distinct points, less distal. There is also noticeable a bright spot near the middle of the forewings. Beneath, the wings and body are lighter than above.

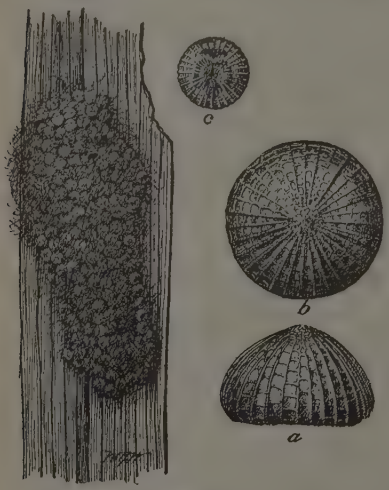

FIG. 16.—Eggs of *Laphygma frugiperda* S. & A. Egg mass at left about twice natural size; *a*, highly magnified egg, side view; *b*, same from above; *c*, egg ready to hatch, larva showing thru the shell. (after Walton & Luginbill.)

There are numerous parasitic enemies of *Cirphis latiuscula*. The ubiquitous *Trichogramma minutum* is doubtless responsible for the destruction of many eggs. The larvae are parasitized by *Apanteles marginiventris* Cresson, and by an *Euplectrus*. The naked larvae of the *Euplectrus* feed on the outside of the caterpillar until they are fully grown and ready to pupate, when they crawl beneath the empty caterpillar skin and spin their brown, oval cocoons. Tachinid flies, *Compsilura oppugnator* Walton, also attack the larvae. The caterpillars have never occurred in sufficient abundance to make the employment of artificial methods of control necessary.

Laphygma frugiperda S. & A.

Laphygma frugiperda is a well-known pest in all the Americas, especially in the United States, where it is known as the fall army worm or southern grassworm. It usually feeds on grasses or allied plants, but when occurring in enormous numbers and having destroyed its usual host plants it will attack almost any green vegetation. In Porto Rico it is a serious pest of corn and it is sometimes locally abundant on cane. Some caterpillars will usually be found in any pasture and in low pastures of *malojillo* grass, especially those subject to flooding, the grass may be entirely destroyed. Caterpillars are most abundant during the fall and winter months and at this season of the year constitute one of the principal enemies of young corn, while they may entirely defoliate young *gran-cultura* cane and, although not killing the plants, may set them back so that they never catch up with unattacked plants.

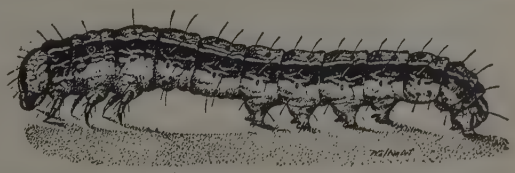

FIG. 17.—Larva of *Laphygma frugiperda* S. & A. Enlarged 2 times. (after Walton & Luginbill.)

The eggs (Fig. 16.) are deposited in clusters, usually on plants on which the young caterpillars can feed, but sometimes on boards, posts, or stones in the field. The number of eggs in a clusters varies from less than 50 to more than 200. When the clusters are large the eggs are placed in tiers, one layer above another. The female moth covers the eggs with a light grey, felty covering. The individual eggs are spherical, glistening pearly or greenish white, about .5 mm. in diameter, with minute vertical ribs. They hatch in three or four days after deposition.

FIG. 18.—Pupæ of *Laphygma frugiperda* S. & A. (after Walton & Luginbill.)

The caterpillars when they first issue from the eggs are about 1 mm. long, grey, with a comparatively large black head. They feed together for a time, devouring the egg shells, and then disperse in search for other food. Even when very small they travel considerable distances and are aided in their progress by the wind. When the eggs have been placed on trees or fence posts the larvae suspend

themselves in the air by a fine silken thread which, being broken by the wind, serves as a parachute to carry the little caterpillar to a considerable distance.

The young caterpillars at first feed only on tender foliage, usually chewing off the epidermis from one surface of a leaf, but later they devour entire leaves. Except when young, caterpillars kept in confinement attack one another and cannibalism occurs normally in the field when they are abundant, and is an important factor in reducing their numbers under such conditions. Larvae reared in the laboratory at Río Piedras in May became full grown in twenty-one days after hatching, moulting six or seven times. With each molt there is a change in coloration and an increase in size, the caterpillars being about 32 mm. long when full grown. The general color of the large caterpillars (Fig. 17.) is olive green, with darker stripes laterally and more transparent and greener, from the food seen within, beneath. On the dorsum of each of the abdominal segments are four large dark spots which outline an isosceles trapezium. These spots and an inverted Y of white, light grey, or light yellow, on the yellow-brown head are constant characters by which the larvae may be identified.

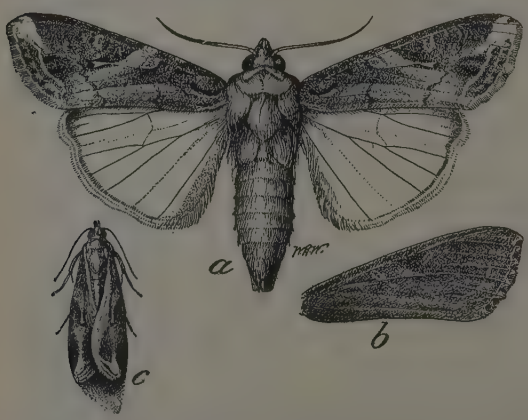

FIG. 19.—Adult of *Laphygma frugiperda* S. & A: *a*, Male moth; *b*, right front wing of female moth, both about twice natural size; *c*, moth in resting position, natural size. (after Walton & Luginbill.)

The caterpillars feed mostly at night, except on dark days or when the food supply becomes nearly exhausted. They usually remain hidden during the day, on the ground at the base of their food plant, or on sugar cane and corn, in the central whorl of leaves. When their food supply in one place becomes exhausted they often

start moving in large numbers, to which habit is due the common name of army worm.

When ready to pupate, the caterpillar burrows into the soil to a depth of about an inch, where its movements hollow out a little chamber scarcely larger than its body. The pupa (Fig. 18.) is about 15 mm. long, glistening, dark reddish brown, rounded at the head end and pointed at the other. The pupal stage lasts from ten to twelve days.

The adult moths (Fig. 19.) show considerable variation in coloration and markings, most individuals being variants from two general types. In one type the upper surface of the forewings is grey-brown, with markings indistinct or lacking; in the other the forewings are rather attractively marked with white, black, yellow-brown, red-brown, and pale blue. The hind wings are glistening white, bordered with grey-brown, both above and below. The body and underside of the forewings are light grey-brown, darker on the upper side of the thorax. The moths remain inactive and hidden during the day; the activities of flying, feeding, mating, and laying eggs being carried on at night.

The parasites and predators on *Laphygma frugiperda* are numerous in Porto Rico. Three tachinid flies, *Frontina archippivora* Will., *Gonia grassicornis* Fabr., and *Archytas piliventris* v. d. W., are possibly the most important in destroying the larvae. Their eggs are laid on the head or thorax of the larvae, into the bodies of which the young maggots bore. The maggots feed within the caterpillars and finally cause their death.

The female of *Chelonus insularis* Cress., after removing a portion of the covering of hairs from the egg cluster, lays its eggs in the eggs of the moth. Caterpillars from these eggs issue normally, but they contain the maggots of the wasp which kill them before they are more than half grown. The small caterpillars enter the soil as if to pupate, but soon die, and cocoons of the parasite will be found within the shriveled remains of the host caterpillar.

Caterpillars are also killed by *Apanteles marginiventris* Cresson and two other parasites, common in Porto Rico, *Trichogramma minutum* Riley and *Euplectrus comstockii* Howard, have been recorded as parasites of it in the United States.

Two entomogenous fungi, *Botrytis rileyi* Farlow and *Empusa sphaerosperma* Thaxter, attack the larvae; the fungous growth appearing externally after the caterpillars are dead.

A carabid beetle, *Calosoma alternans* Fabr., and an assassin bug,

Zelus rubidus Lap. & Serv., have been observed to kill caterpillars in the field. The blackbirds, *mozambique* or *chango,* and *ani* or *judío,* and lizards destroy many caterpillars and moths, and chickens and turkeys devour the caterpillars with avidity.

The injury done by the small larvae of *Laphygma frugiperda* is not especially noticeable, but when the caterpillars are more nearly full grown the amount of food they consume becomes so great that overnight the grass or cane may be entirely defoliated. Unfortunately, it is usually not until this time that the presence of the worms is noted, and, because of their being nearly mature, and the amount of damage of which they are capable being nearly complete, the beneficial results of control measures which may be employed are greatly reduced. Also, when the caterpillars have been abundant in a certain section another destructive brood of the worms does not often follow. This is because most of the caterpillars are usually destroyed by the tachinid flies, but they do not kill most of the caterpillars until they are full grown and have finished their injury to the crop. The poisoning of such parasitized caterpillars will result adversely, as its effect is to kill the beneficial parasites—the tachinid flies—in an immature stage inside the caterpillars, which if left unmolested would prevent another outbreak of the army worms.

A sharp lookout should be kept, therefore, for the presence of the small larvae and when they are observed to be present in numbers on young cane, the application of powdered arsenate of lead will kill them before the damage is done. The poison can be dusted on the plants undiluted or mixed with ashes. No expensive equipment for its application is necessary, as it can be sifted out of a burlap bag or shaken out of a can with nail-holes in the bottom. The modern mechanical dusters, however, avoid waste of the poison and get it on more thoroughly and evenly. A very little bit of poison dusted into the whorls of young corn plants will make a surprising difference in getting an even stand, as these caterpillars are always present and usually in considerable and destructive abundance in corn in Porto Rico.

As the caterpillars prefer to feed on grass, injury to cane and other cultivated crops often occurs in fields that have been allowed to become grassy. When the caterpillars are so abundant on grass that they defoliate it, or it is destroyed by cultivation, they then quite naturally begin feeding on the crop. For this reason cane

fields, and low-lying land immediately surrounding them, should be kept as free of grass as possible.

Remigia (Mocis) repanda Fabr.

Although *Remigia repanda* has a wide distribution in the Americas, the only records of it as a pest of sugar cane are from Trinidad by F. W. Urich and from Demerara by G. E. Bodkin. In Porto Rico the caterpillars are often found with those of other species, especially *Laphygma frugiperda* and *Prenes nero*, and in such cases can cause rather serious damage.

The eggs have not been observed in Porto Rico, but Bodkin reports that they are "considerably less than one-sixteenth of an inch in diameter, of a green color, and laid on the blades of the grasses."

The caterpillars are yellow grey, darker above and below, with numerous fine longitudinal stripes on the lighter sides, colored and marked so that when stretched out at rest they can be scarcely distinguished from a dead cane leaf. Dorsally, at the sutures between the fifth and sixth and the sixth and seventh segments, are large black and white spots, invisible when the caterpillar is straight, but exposed in sharp relief when it is looped up. The caterpillars lack the first two pairs of abdominal legs and progress by looping up their body rather than by crawling, and are called loopers or measuring worms. They are 35 mm. long when full grown.

The pupa is dark reddish brown, with a lavender bloom, and is formed in a slight cocoon under the leaf-sheath or in trash. The moth is yellow-brown with the enormously developed hind legs of one sex covered with a dense mat of hair. The forewings are subequally divided into three areas by darker transverse lines, the more distal area being always sharply defined. There are numerous darker curved and wavy lines in the median area, besides a row of spots in the distal area and a wavy line close to the margin. The hind wings are darker towards the margin, but more, or entirely, uniform in color underneath. The moths have a wing expanse of from 30 to 40 mm.

The Tachinid flies, *Phorocera claripennis* Macq., *Linnaemyia fulvicauda* Walton and *Helicobia helicis* Towns., are the most important parasites of this insect, over nine-tenths of the caterpillars sometimes being killed by them. The black and yellow wasp *Chalcis* near *robusta* Cress, and a yellow Ichneumonid, *Rogas* n. sp., have also been bred from large caterpillars or from the pupae. The Sarcophagid fly, *Sarcophaga sternodontis* Towns., has been reared from the

larvae of both *Remigia repanda* and *Laphygma frugiperda*, and even from white grubs, *Lachnosterna vandinei* Smyth and *L. portoricensis* Smyth. Dr. Aldrich states that this is "a strictly parasitic species as far as known and is an abundant parasite in the West Indies."

Unless the caterpillars are observed when they are still small and poison applied before they have done much injury, it does not appear desirable to attempt to poison them, as the parasites will usually prevent another outbreak in the same or nearby fields during the same season. Indeed, in one case observed, where an attempt to control by spraying with arsenate of lead was made, the delay of a day in getting the poison ready after the injury to the cane had been observed made its application come so late that only a few caterpillars were killed, most of them having already spun cocoons for pupation. From about twenty cocoons collected, not a single moth emerged, all having been parasitized, indicating that there would be no danger of another destructive outbreak of larvae that season, even though the poison had been ineffective in killing many of the caterpillars.

SUMMARY.

The caterpillars which feed on the leaves of sugar cane in Porto Rico are pests of rather minor importance, due largely to their normal natural control by parasites. Those which become butterflies have never been observed to be sufficiently abundant to eat the leaves of more than a few plants in a cane field, but two of those which become moths (*Laphygma frugiperda* and *Remigia repanda*) sometimes, especially in low places, become so numerous as to entirely defoliate considerable areas of young cane. If the caterpillars are observed while they are still small and before they have done much injury dusting with powdered arsenate of lead will kill them and be a profitable operation. The poison is comparatively cheap in first cost and in application and can be applied with inexpensive home-made apparatus. If the damage is not observed until the caterpillars are full grown, poisoning will not only be ineffective in preventing the damage they have caused, but may be harmful. Most of the caterpillars killed may contain the immature stages of beneficial parasites which, if allowed to live, would insure this and adjoining fields against injury from another generation of the caterpillars that season.

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